650MHz cavity processing at FNAL

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PIP-II workshop

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A Partnership of:

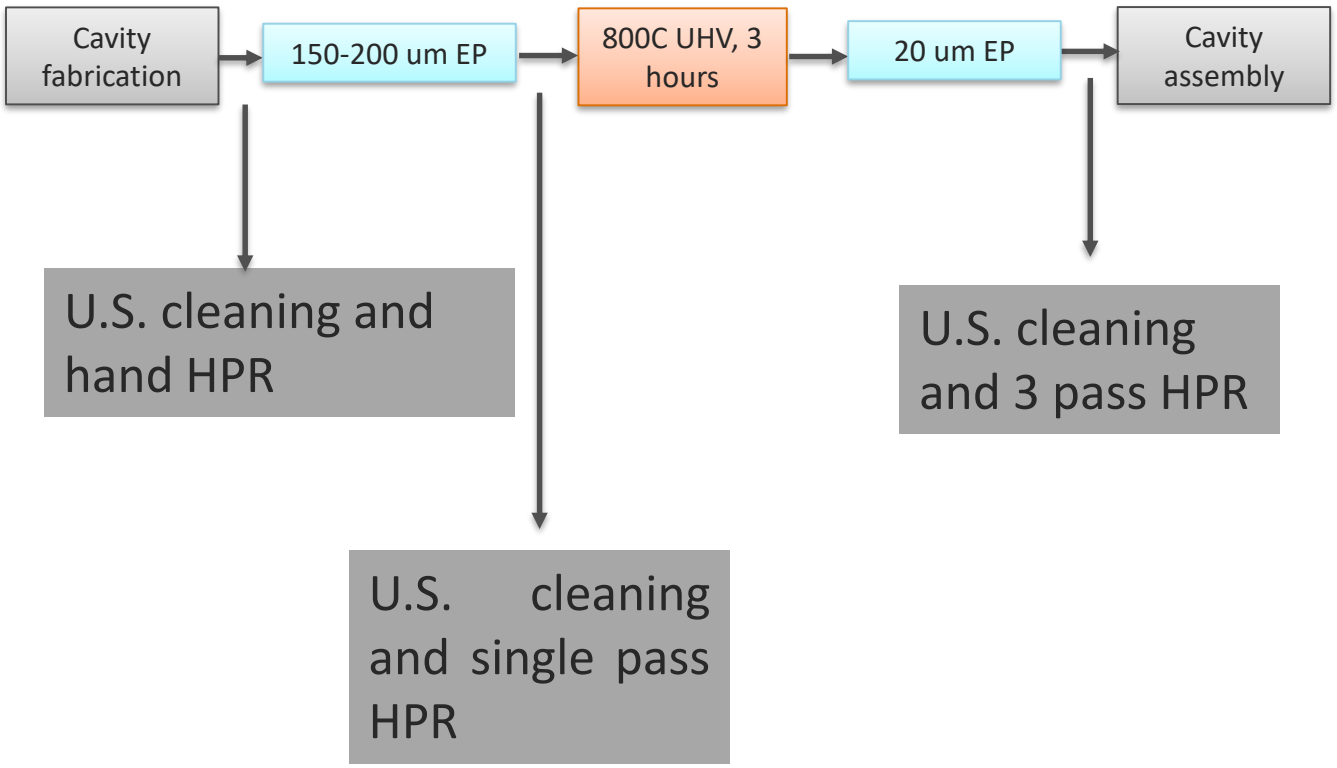
- US/DOE
- India/DAE
- Italy/INFN
- UK/UKRI-STFC
- France/CEA, CNRS/IN2P3
- Poland/WUST

Outline

- Main 650 MHz processing steps
- EP procedure*
- Furnace procedure#
- Summary of cavities performance
- Plan to improve flux expulsion

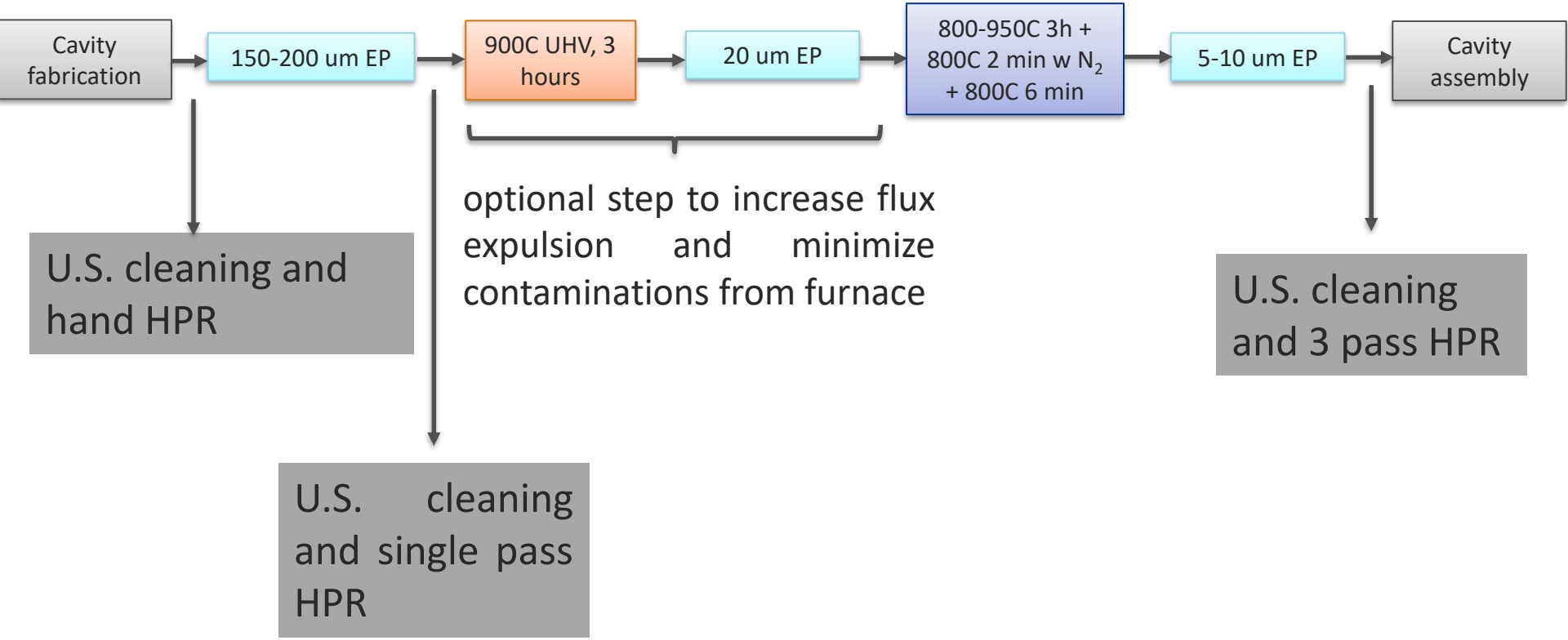
* Thanks to Tom Reid (ANL) for providing significant material
# Thanks to Damon Bice (FNAL) for providing significant material

Main processing steps for EP baseline



U.S cleaning: ultrasonic cleaning of the cavity in warm bath of Liquinox (15-60 minutes in DI water w 1% Liquinox at 50C)

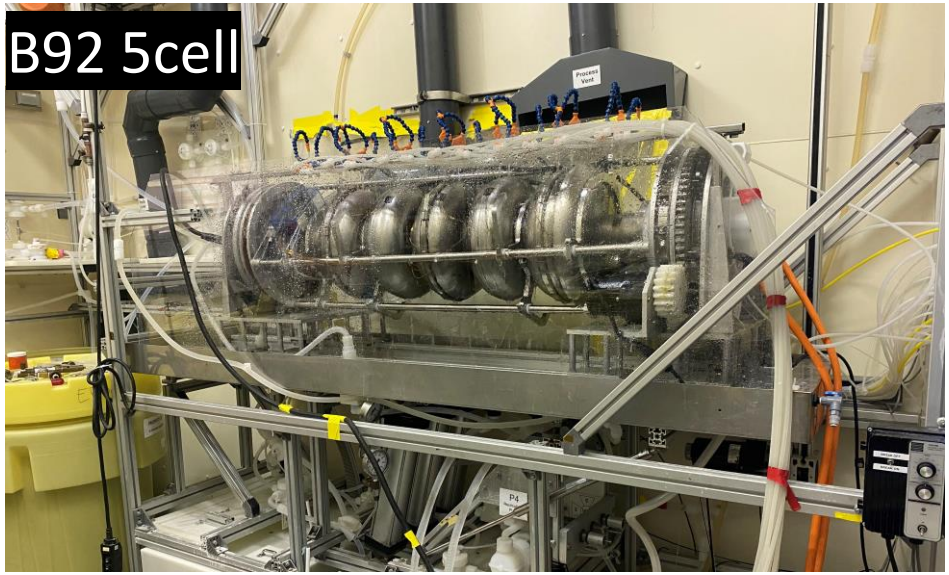
Main processing steps for N-doping

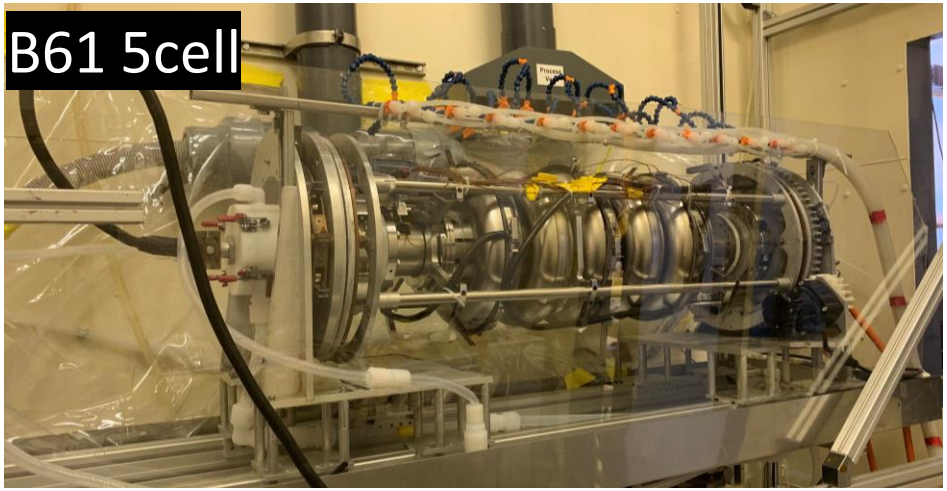


U.S cleaning: ultrasonic cleaning of the cavity in warm bath of Liquinox (15-60 minutes in DI water w 1% Liquinox at 50C)

EP set-up

- Horizontal EP setup at ANL
- Cavity is 60% full of acid and rotates around a fixed cathode inserted along the beam axis.
- External water spray helps to control cavity surface temperatures for more uniform EP. Acid bath is also actively cooled during EP.
- Both the external water-spray system and acid-cooling system are supplied by 10 kW chiller.
- Bulk EP is performed with cavity surfaces temperatures limited to 23C and 18V.
- Cold EP is performed limiting temperature to 13C and 18V.

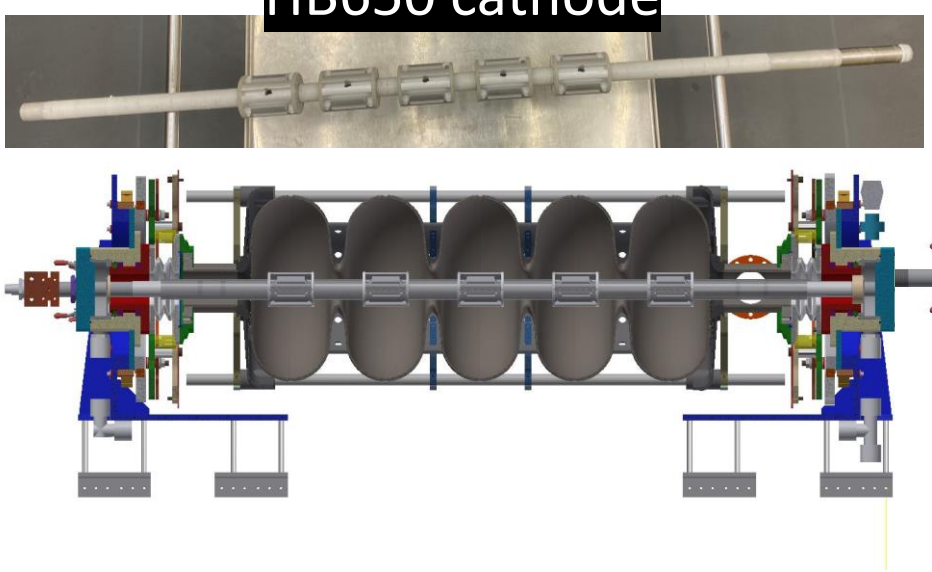




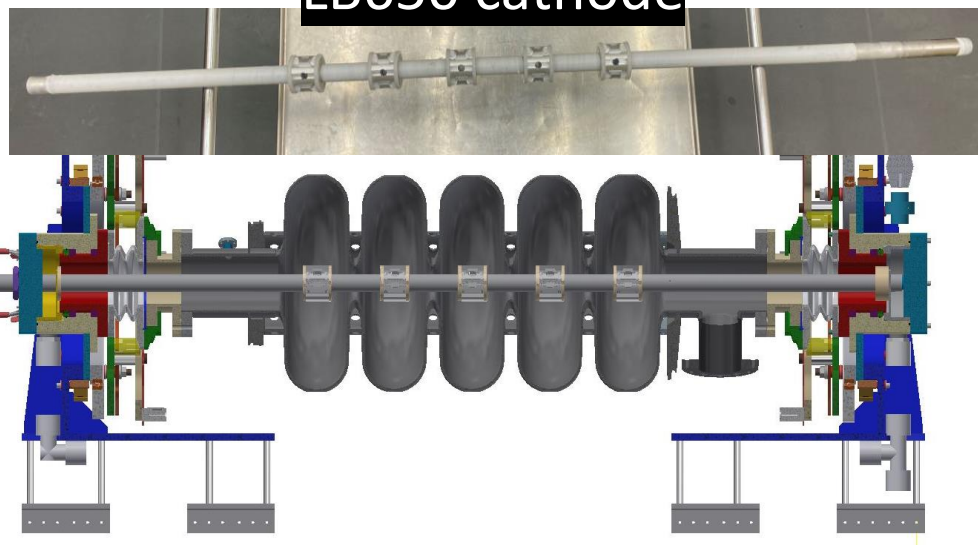
EP cathode optimization for 650

- High-purity Al rod plus donuts in correspondence of cells
- Donut shape needed to increase the cathode surface area so that surface area ratio between cathode and anode (cavity surface) is at least 10:1
- Large cathode surface area helps to lower the over-potential on the cathode and minimize precipitation of Sulphur [H. Tian et al., Quantitative EP studies and results for SRF production, Proc. Of SRF 2011 – WEIOA01].

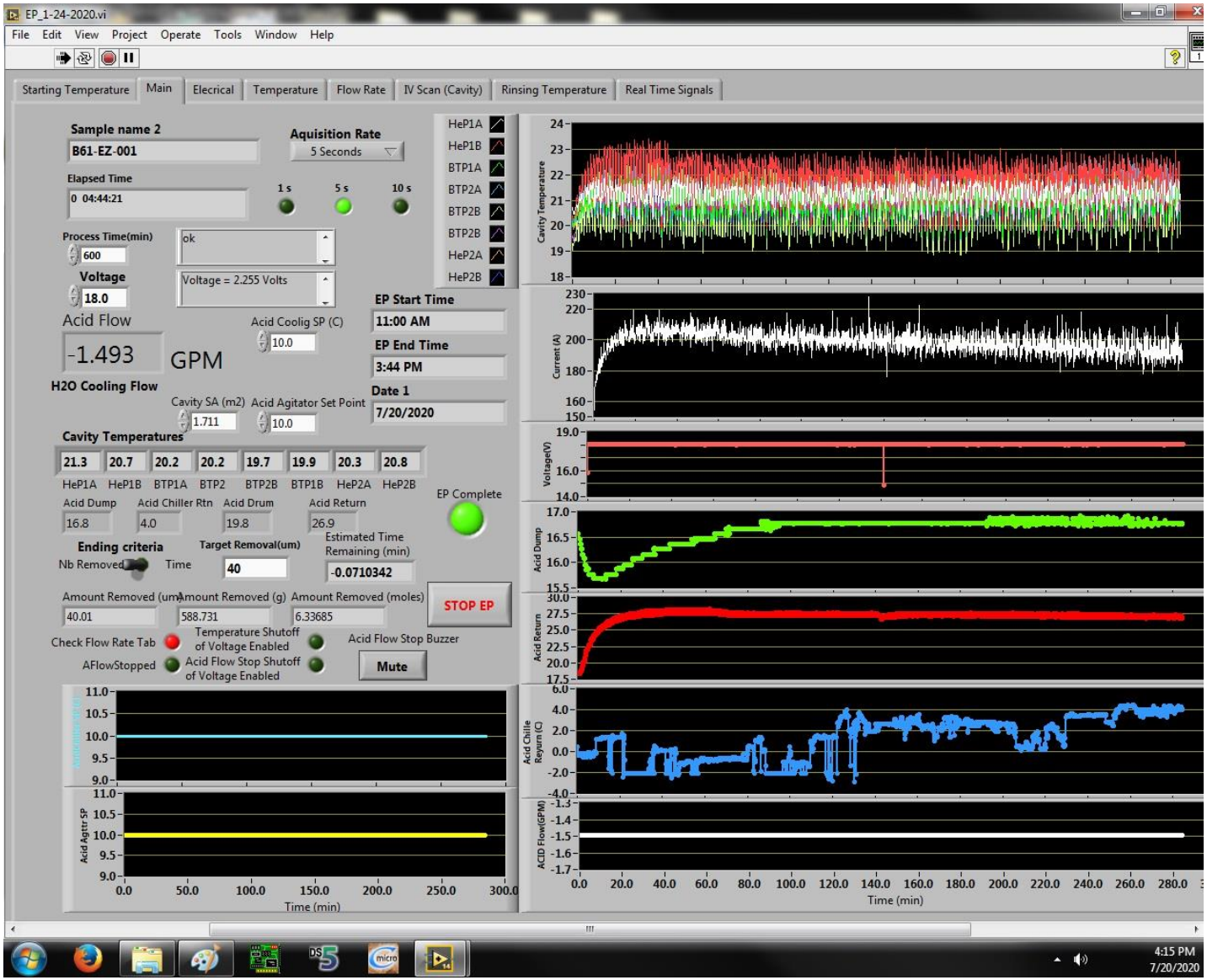
HB650 cathode



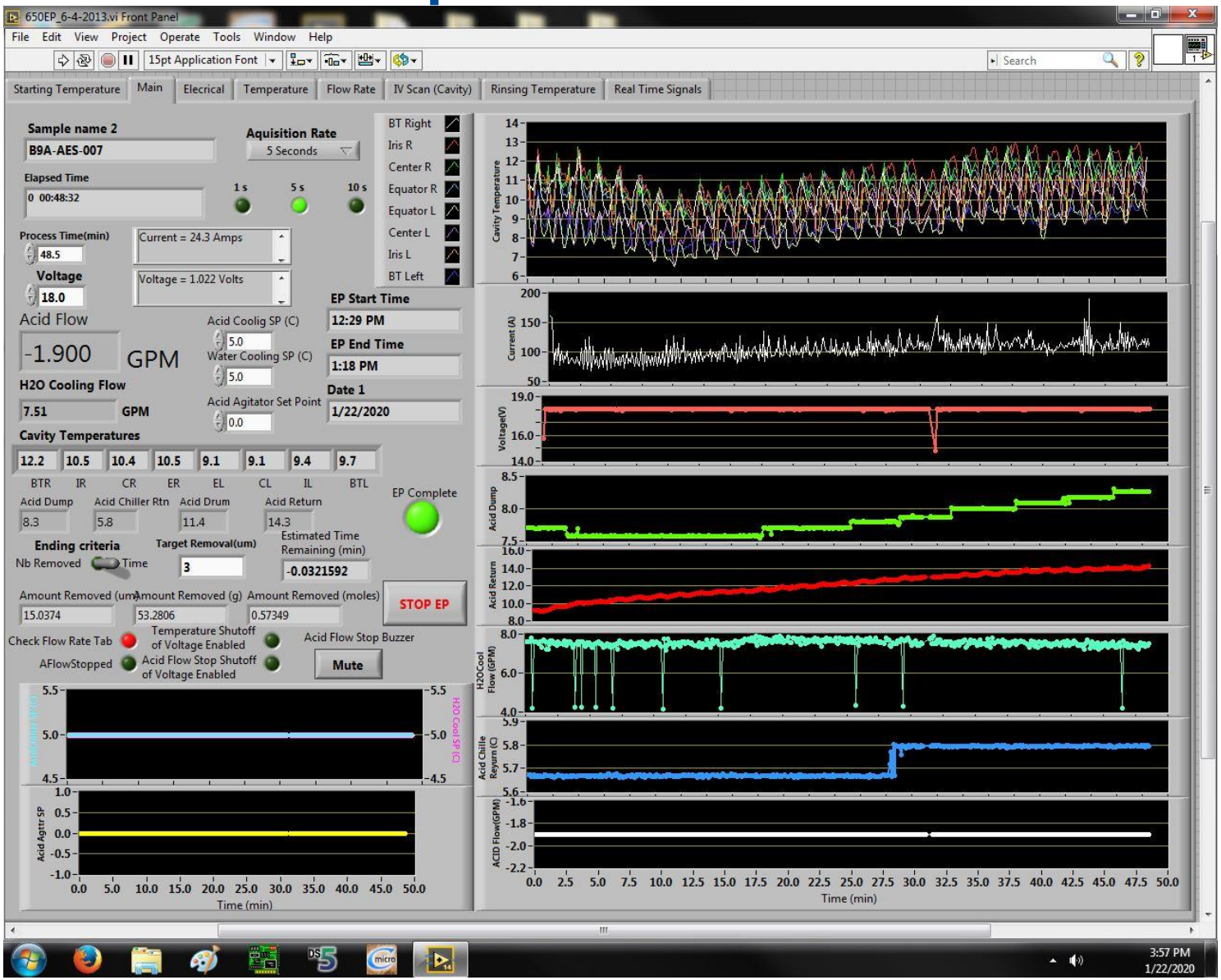
LB650 cathode



Bulk EP example

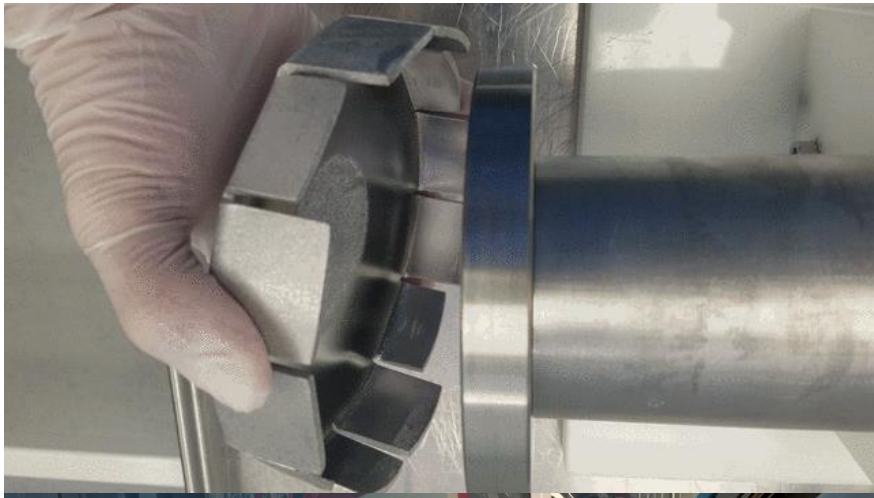


Light cold EP example

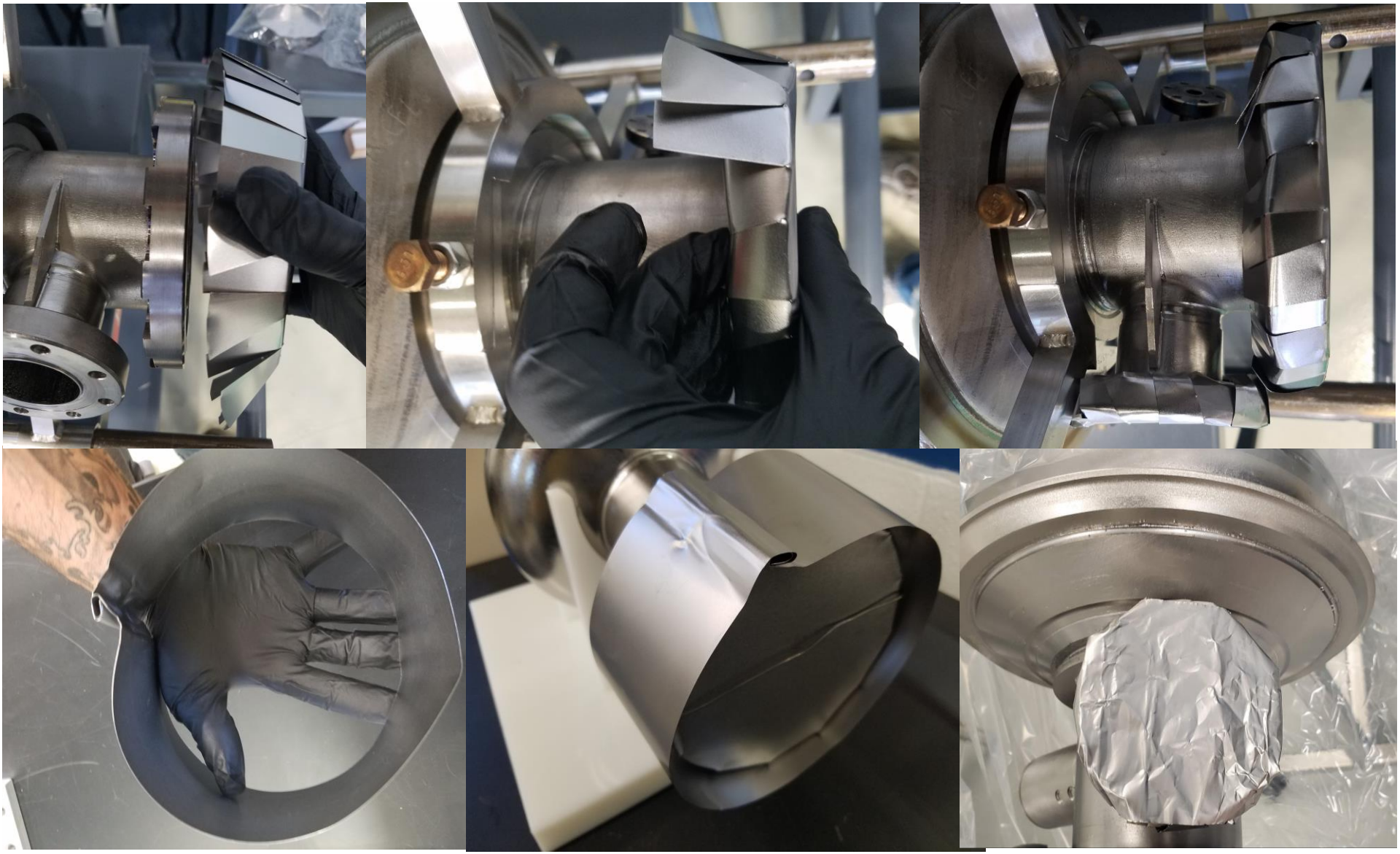


Furnace procedure

- Nb caps are used around beampipe, FPC and pick-up flanges
- Nb foils are then wrapped around the caps
- Caps and foils receive flesh BCP before each use
- The use of caps and foils is fundamental to avoid contaminants -from furnace and Ti on cavity flanges- to reach the inner cavity surface

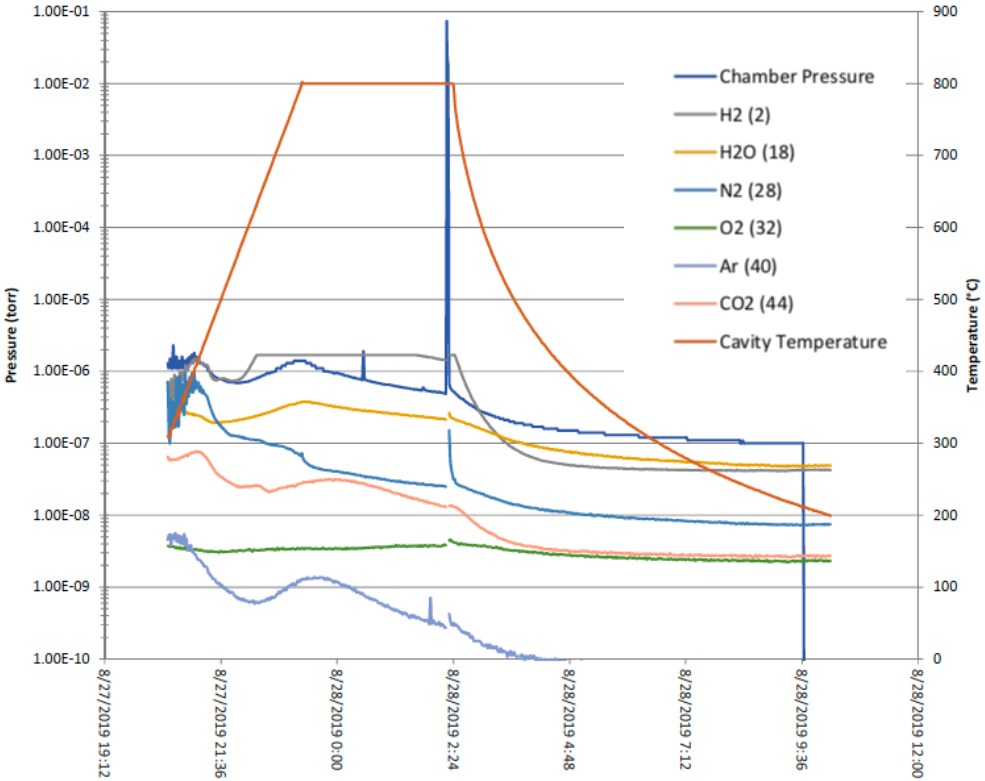


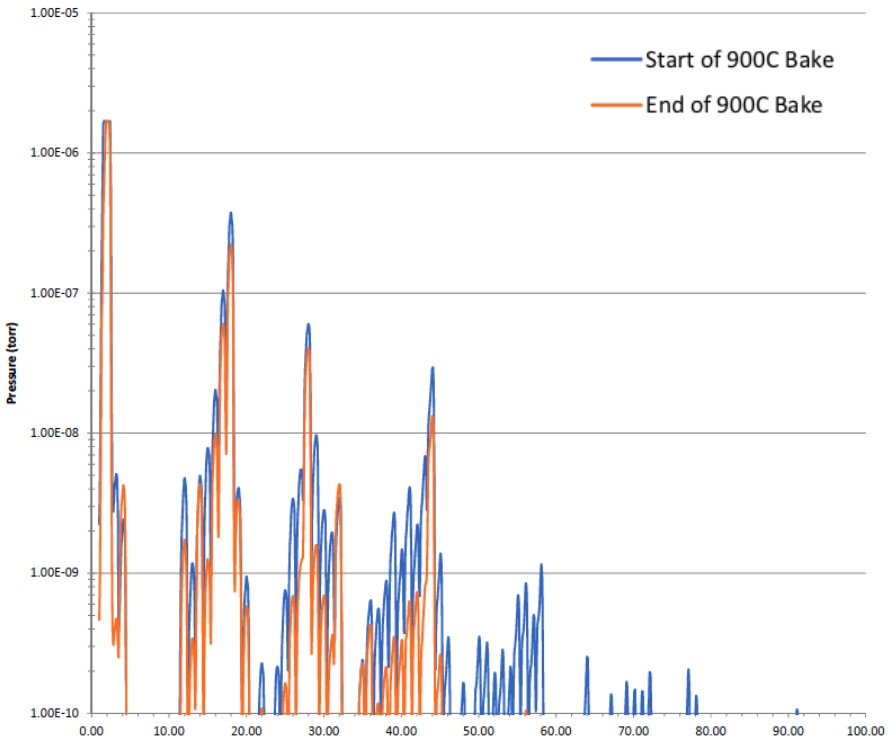
Caps and foil assembly



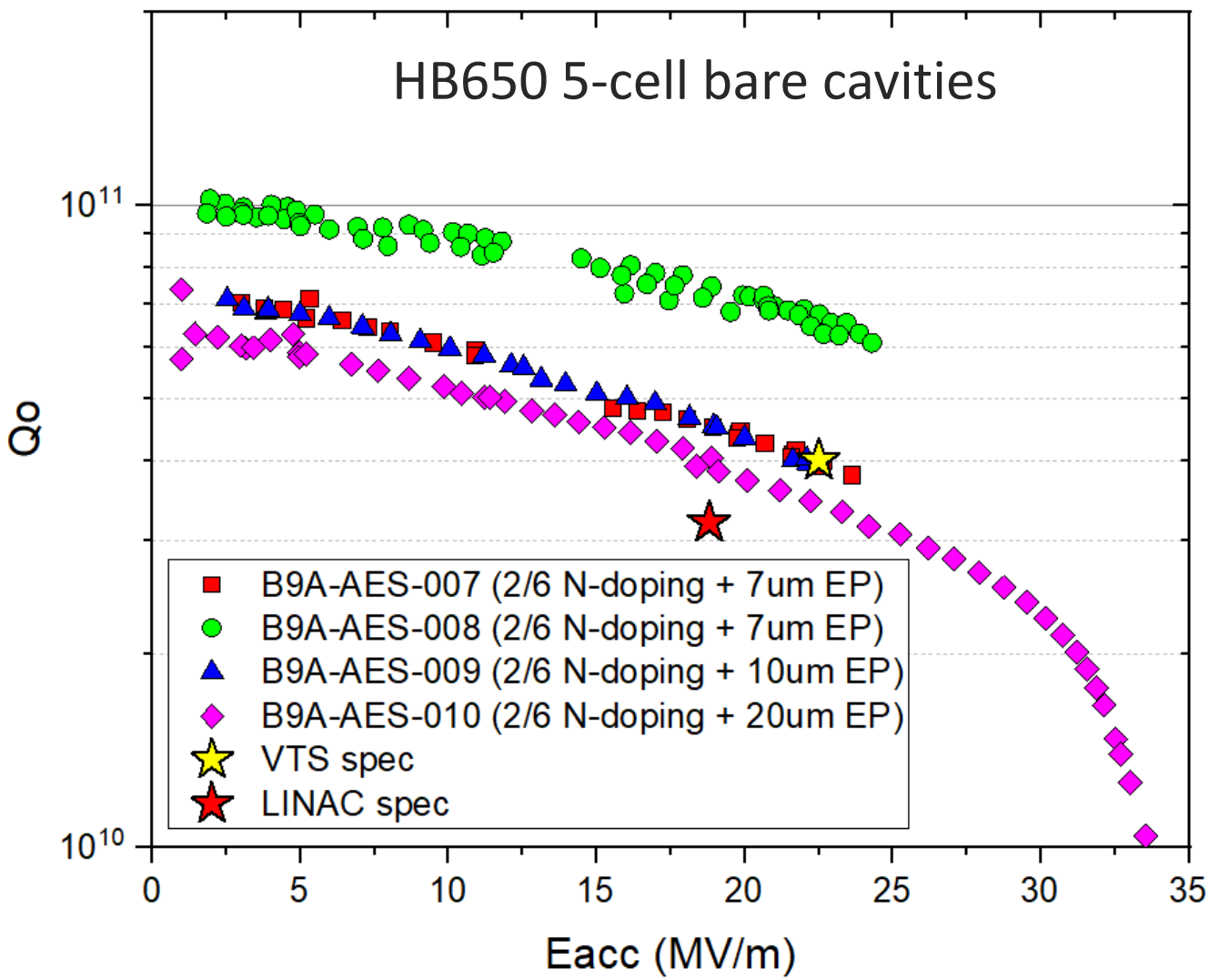
Furnace run example

- Example of 2/6 N-doping treatment (900C 3hours + 800C 2 min w N2 + 800C 6min w/o N2)



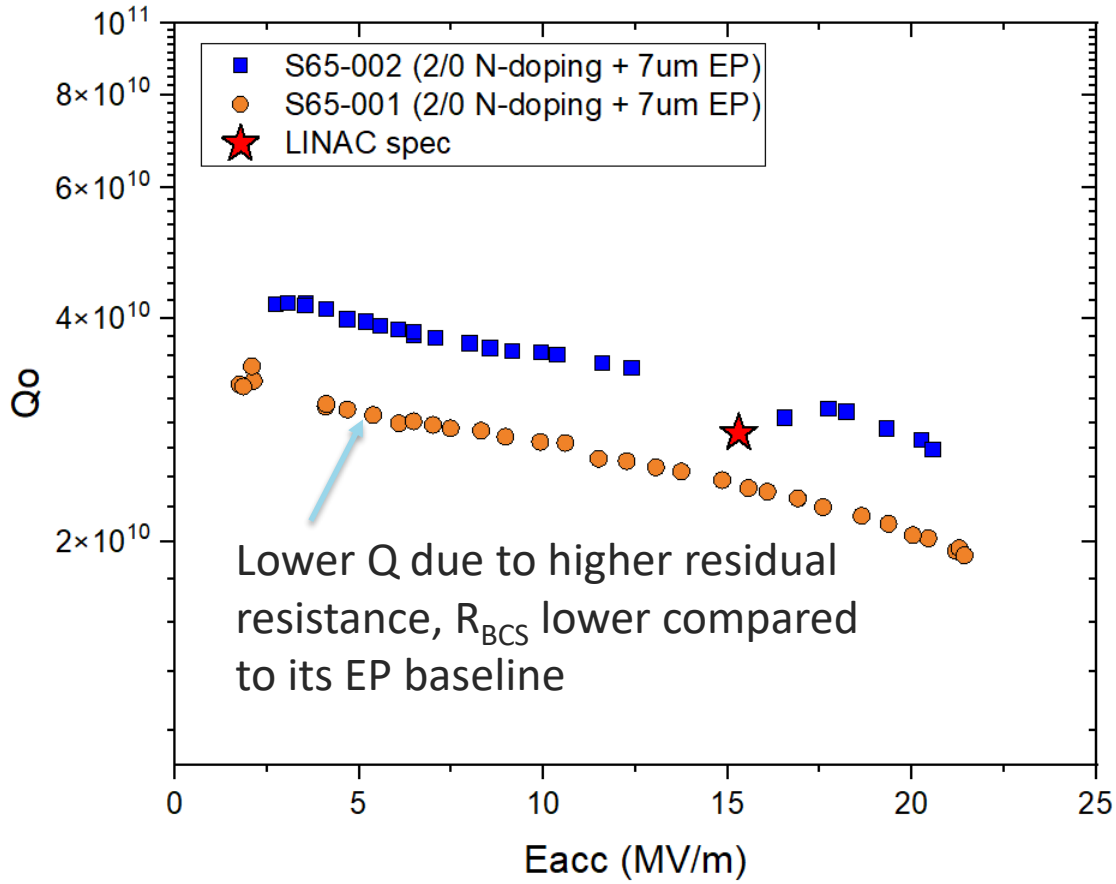


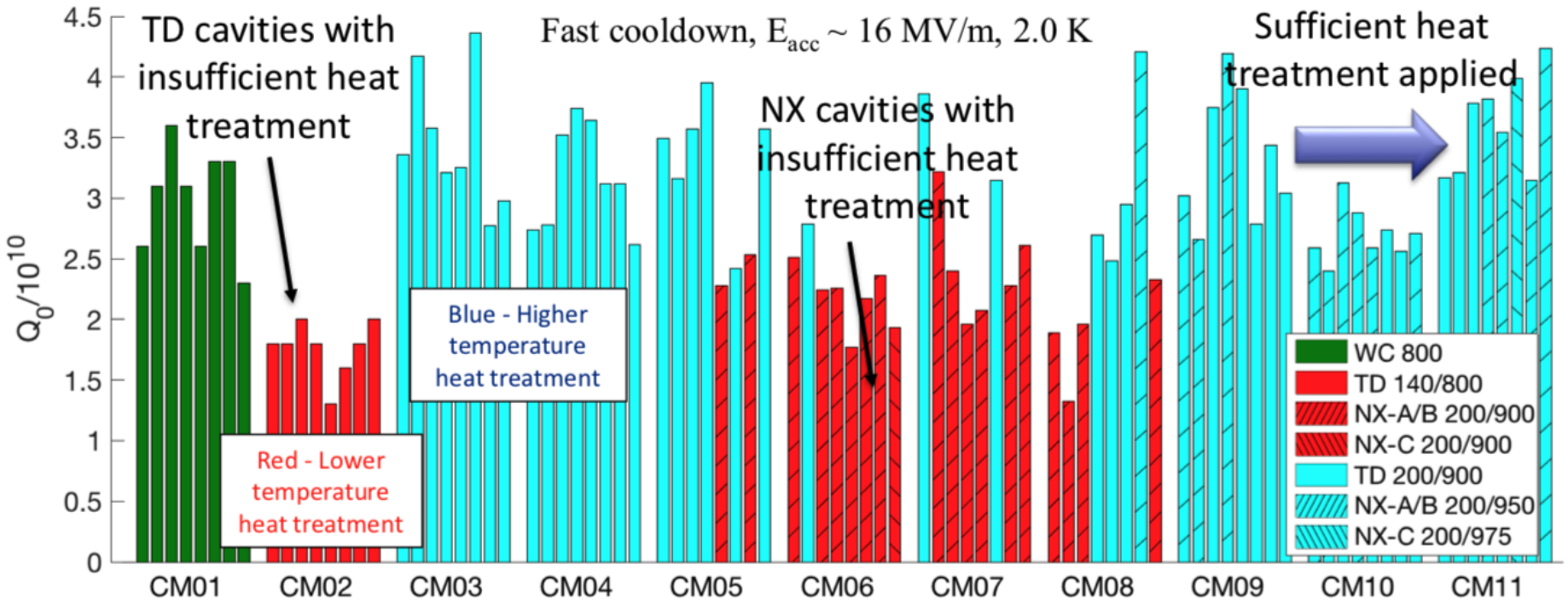
Summary 5-cell cavities performance at 2K



Summary 5-cell cavities performance at 2K

- Very first attempts of N-doping in lower beta cavities!
- MSU 644MHz β=0.65 5-cell bare cavities



Plan to improve flux expulsion

- To improve flux expulsion we may need to heat treat cavities at T > 800C
- Example of cavities performance in LCLS-II CM as a function of Nb vendors and heat treatments: